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THE USE OF SYSTEMS ANALYSIS AND MANAGEMENT TECHNIQUES IN PROGRAM PLANNING AND EVALUATION.

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THIS PAPER, PRESENTED AT THE SYMPOSIUM ON THE APPLICATION OF SYSTEMS ANALYSIS AND MANAGEMENT TECHNIQUES TO EDUCATIONAL PLANNING IN CALIFORNIA, JUNE 12-13, 1967, DISCUSSES THE USES OF SYSTEMS ANALYSIS AND MANAGEMENT TECHNIQUES IN PROGRAM PLANNING AND EVALUATION. THE DISCUSSION FOCUSES ON THE GENERAL CONCEPT OF MANAGEMENT SYSTEMS AND, WITHIN THIS CONCEPT, THE NATURE AND FUNCTION OF MANAGEMENT INFORMATION SYSTEMS. THROUGHOUT THE PRESENTATION AN ATTEMPT IS MADE TO INTERRELATE THE CONCEPTS OF SYSTEMS ANALYSIS, PROGRAM PLANNING, AND EVALUATION. ALSO PRESENTED IS AN OVERVIEW OF NETWORK-BASED MANAGEMENT SYSTEMS OF WHICH THE TWO MOST POPULARLY KNOWN EXAMPLES ARE PERT AND THE CRITICAL PATH METHOD. THIS PAPER WAS PRESENTED AT THE SYMPOSIUM ON THE APPLICATION OF SYSTEMS ANALYSIS AND MANAGEMENT TECHNIQUES TO EDUCATIONAL PLANNING IN CALIFORNIA (CHAPMAN COLLEGE, ORANGE, CALIFORNIA, JUNE 12-13, 1967). (HW)

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The Use of Systems Analysis and Management Techniques In Program Planning and Evaluation[1]

Desmond L. Cook

Introduction

It gives me a great deal of pleasure to have been invited to make a presentation at this symposium for two reasons. First, I welcome very much the opportunity to become personally acquainted with each of you and to acquire greater familiarity with the overall dimensions of the Operation PEP project. Second, I am in agreement with the general idea of Operation PEP that systems approaches offer a significant means for bringing about improvements in the educational environment.

Dr. Estes has highlighted the need for planned change in education in his keynote address. As I have listened to this concept being bantered about during the last couple years, I fear, that it is very similar to the comment about the weather attributed to Mark Twain. That is, everybody is talking about planned change but very few seem to be doing anything about it. My knowledge of the work that is going on under the duration of Drs. Corrigan, Kaufman, and Miller represents, in my thinking, one of the few systematic and concentrated efforts to develop the needed leadership and to provide the techniques to bring about desired changes on a planned basis in the area of education.

The development of the concepts and procedures underlying Operation PEP turns out to be a good case of foresight. This remark is made in view of the fact that within the last couple of months I have become involved with a U. S. Office of Education project concerned with the establishment of discreet but comprehensive planning agencies within a group of seven states. It is hoped that the process of developing and establishing these state planning agencies could then serve as a model for the other states to follow. In thinking about this project, it seems to me that the ideas behind Operation PEP are both highly relevant to and timely for this projected activity. The existence of both Operation PEP and the seven state project serve only to reinforce my thinking that if any significant changes are to be made in education within the school districts, each state, and throughout the country, systematic planning efforts offer the greatest opportunity to accomplish this goal. Unfortunately, as desirable as our goal is, the educational leadership is handicapped by a lack of comprehensive skills and techniques through which it can achieve the goal. It is my understanding that the purpose of the project in which many of you have been participating during the past months is to remedy this situation by providing the educational leadership within each school district with techniques and skills which they can use to facilitate movement toward the goal.

Drs. Kaufman and Corrigan have presented some of these techniques with their descriptions of systems analysis and synthesis. The task

EA 001 347

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assigned to me is to discuss the use of systems analysis and management techniques in program planning and evaluation. A more specific context for my comments can be secured by noting that the presentation relates primarily to the step labeled "Establishing Management and Control Sub-System" in their total list of steps. To avoid some redundancy, I intend to deal primarily with the purpose and functions of management techniques as they relate to program planning and evaluation.

The presence of such a topic in this symposium is important because management problems are an inherent aspect of any programmatic effort. This statement is reinforced by the recent observations of Andrew (1) on the management problems in applied social research. Andrew indicates that the payoff from much social research has been limited because of various problems which can be classified into two major types of stresses--those inherent in managerial arrangements and those growing out of program and research demands which he labels the professional context. Time does not permit a detailed presentation of his comments relative to each type. For the moment, it is perhaps sufficient to say that his observations are not unique since there appears to be little done in the preparation of researchers, let alone school administrators, with regard to the processes of management although both groups are often highly prepared in their professional substantive area. Consequently, many action programs fail to reach full fruition. To prevent needless repetition of this situation it is appropriate that some time be given to the topic of management techniques when talking about programmatic efforts.

The concept of management techniques has several meanings. Let me state that this presentation will not focus upon techniques relating to topics such as how to deal with personnel problems, office organization, or methods of financial accounting. Instead, the focus will be upon the general concept of management systems and within this concept, the nature and function of management information systems. During the course of the presentation, an attempt will be made to interrelate the concepts of systems analysis and program planning and evaluation.

Program Planning and Evaluation

To provide a context for the subsequent discussion of management techniques, I should like to review briefly the concept of program planning and evaluation.

It is very much "in" today to talk about programmatic thrusts in various fields. We hear about the space program, defense program, research programs, air pollution programs, and so on. Like many other concepts that are "in" no one seems fully to have reached consensus as to exactly what is being talked about. My remarks will probably not solve this problem but I would like to give you my idea of what is being talked about when the topic is program planning and evaluation.

Whenever program is mentioned, I think primarily of a carefully organized effort utilizing a "critical mass" of resources moving toward the achievement of an objective which the culture has agreed upon as

being worthy of being attained. The elimination of polluted air, poverty, dreaded diseases like leukemia, are worthy program objectives. It can almost be axiomatic that when there is no objective there is no meaningful program. Having established the goal, a plan is developed to accomplish it. Briefly, a blueprint or a roadmap for the future is constructed. In doing so, an attempt is made to build the plan to conform to the parameters of time and cost that it will take to achieve the performance level stated in the objective. Having established the plan, the program moves into an operational phase which is essentially the carrying out of the activities that are expected to lead to the objective. As work moves along and tasks are accomplished, there is a need to evaluate progress to see how well the actual work is going in terms of how it was planned to go. Such questions as is the program ahead or behind schedule? Is the rate of expenditures too fast? Where are problems developing? are illustrative questions which are raised in evaluating program status. I would call your attention at this time to the fact that evaluation is being defined here in terms of what management refers to as process control as opposed to concerns about the quality of the end product. It is through the comparison of what <u>should</u> be happening to what is <u>actually</u> happening that problem areas are identified for subsequent management actions during the course of the program. With this brief background on program planning and evaluation, let us turn our attention to the topic of management techniques.

Management Techniques

The success of any programmatic effort will depend greatly not only upon the initial planning effort that goes into it, but just as importantly, upon the employment of a viable management plan by the persons charged with the responsibility for carrying out the program effort. The success of such a large scale program as the lunar landing is due not only to the professional technical and scientific competence assembled for the program but also to the managerial competencies and skills brought to the program. This latter point is often overlooked by most of the general public until there is a disaster such as the recent Apollo fire when the program management was subjected to heavy and, in my opinion, much undeserved criticism.

To talk about management techniques without some general reference to the nature and function of management would be an incomplete activity since such techniques or tools are basically designed to assist management in carrying out its responsibilities. There are many definitions of management but basically most definitions focus upon the responsibilities of organizing, directing, and controlling personnel and resources to carry out the accomplishment of an objective.

It is also generally recognized that a manager's principal functions are those of problem identification, decision-making, and the prevention of future problems. Our present state of knowledge about these three functions is that they cannot be accomplished without some systematic procedures. It is perhaps therefore more appropriate to talk about management systems rather than management techniques.

It might be helpful to us if we were to define what is meant by a management system. In their recent book on network based management systems, Archibald and Villoria (2) provide us with a useful working definition.

> We may define a management system as a set of operating procedures which personnel carry out to acquire needed information from appropriate sources, process the data in accordance with a pre-programmed rationale, and present them to decision makers in a timely, meaningful form. Most contemporary systems involve manual data collection and input, machine processing, tabular and graphic output production, and human analysis and interpretation. Thus we can say that the systems collect, synthesize, process, transmit, and display information, which flows from a primary source, through an editing, computation, and selection process to the manager.

Two principal ideas are highlighted in this definition. First, the systems are designed to provide information. Second, the final decision-making operation is left to the manager. Some sophisticated systems do have what is called pre-programmed decision-making as an inherent part of them. Most systems, however, still rely upon the use of humans to make non-programmed decisions. Further, most of the systems developed are primarily aimed at facilitating the process control responsibility given to a manager. The focus of control is nevertheless related to the planning effort that has gone on before. It can be almost stated as an axiom that if one establishes a pian, he intends to exercise control to make sure that the plan is accomplished.

In view of the definition presented above, it seems more appropriate to label such systems as management information systems. To visualize how such systems operate within the management situation, picture a triangle divided into approximately three equal horizontal sections. The bottom section of this triangle consists of elements of information--or what is commonly referred to as the data base. What and how much information should be in this base is open to question but generally within a program planning effort the information assembled relates to time, cost, and performance. Such information is included because most program efforts operate within a set of time/cost/performance parameters. That is, there is usually some goal to be achieved which has specified criteria of accomplishment and this goal must be reached within a schedule period of time and certain budget limitations. Most military weapons systems operate under such conditions as do many non-military programs such as the lunar landing or space programs. Many programs funded under the Elementary and Secondary Education Act also operate under a set of similar parameters. Reports to management stem from this data base on schedule reporting periods (i.e., daily, weekly, monthly, etc.). In terms of management levels, this base section is often equated with immediate performing departments or units concerned with the specific day-to-day tasks, or <u>operational control</u> as it is called (5).

The middle section of the triangle represents operating management whose primary concern is to assure that resources are obtained and used effectively and efficiently in accomplishing the objectives. To do this, information requests and demand reports are secured from the data base. Such reports are secured often in addition to the schedule reports sent upward from the data base. The main function of this level is that of control.

The top section of the triangle represents general or executive management which is primarily concerned with policy level decision-making. Focus here is often on information for the planning effort as contrasted to information for the middle section which is focused upon control. There are times however when top-level management desires and uses the information for control purposes.

Within this structure, different kinds of information (i.e., data) are needed by the three levels for different purposes. It is important to know the information requirements at each management level along with the description of the data and how it interrelates in order to establish a useful data base.

It has been generally agreed upon that managers operating within the program or project planning and evaluation situation require data or information relating to time or schedules, costs, or resources, and performance, reliability, or quality of objective accomplishment. Of these three types of data, the most common data obtained and used in a program situation is that of time or schedule.

While seemingly easy to think about, the development and use of management systems is not so easy because a system designed for one purpose may not be suitable for a different purpose. For this reason, numerous management systems have been developed over the past several decades to facilitate the manager's task. Three general types of systems have been developed each designed to serve a different purpose. One group of systems relates to the quality characteristics of a product. A second category of systems related to the operations involved in producing the product. A third group of systems relate to the administration involved in carrying out the operations.

It would not be possible to discuss all three types of systems within the time allotted so I have chosen to talk primarily about selected operations-related systems which have become increasingly popular during the past decade because of their relatively high degree of success in carrying out research and development activities within the military-industrial complex of our society. The application of such techniques to the field of educational research and development is just beginning but their value has already been demonstrated and they should grow in increased usage during the next decade.

Network-based Management Systems

Any formal or structured management technique that is to be meaningful and useful for programs of planned change must help us to accomplish three tasks (3). The first task is to develop a general program model based upon a logic derived from the substance of the work to be performed. Major program elements are then identified which in turn are further reduced into smaller work packages. The second task is to sequence the order of effort by determining the logical relationships between the events. It should be recognized that within the research and development situation, any such ordering will be tentative and be subjected to continuous modification. The third task is to provide a time frame so as to establish a basis for determining present and projected resource requirements and to provide a schedule for the completion of events and activities. Further, any such technique must be easily understood, help to establish priorities, deal with the uncertainty problem, be predictive and help to forecast problem areas in advance, and enable us to manage by exception.

The specific group of process-related management systems that will help us to accomplish the above tasks are those referred to as network-based management systems. The two most popularly known examples of these systems are those of the Program Evaluation and Review Technique (or PERT) and the Critical Path Method (or CPM). While each of these systems has distinctive characteristics, they do have sufficient similarity that both can be discussed under the more general concept of network techniques. Time does not permit a detailed presentation of system characteristics so only an overview can be presented here.

The implementation of network techniques as a management information system for a research program or project can be subdivided into two principal steps for discussion purposes. The first is planning and the second is control. Operationally, both are highly interdependent and go on concurrently.

The first step in planning is to breakdown or breakout the work that has to be accomplished in order to achieve the prime and supporting objectives. This process is referred to as establishing the work breakdown structure. The process is a top-down activity with prime objectives at the top being broken down into successive smaller and smaller units until some point is reached at which there seems to be no additional value in breaking out the particular tasks to be done. The final unit of breakdown is referred to as a work package. It is at this point that the work breakdown structure process and the mission profile derived from a systems analysis procedure become highly interrelated. Once the analysis program has been carried through the mission, function, and task analyses stages, the work breakdown structure required for network planning should have been pretty well established. A major integration of systems analysis and management techniques for program planning and evaluation takes place at this point.

Having once identified the various work packages that have to be done to accomplish the mission, a network is established. The network is a graphical representation of the plan showing the logical sequence and interdependency of work to be accomplished from the time the program is initiated until its final termination. Individual tasks to be accomplished which utilize resources and consume time are called activities. Activities are usually represented on the network by a straight line with an arrowhead to show flow. The start and/or completion of an activity is referred to as an event. Events are points on time and do not consume time or resources. They are represented on the network by a circle or other geometric figure. The work flow in the network is always from left to right. The amount of detail to be included in a network is a function of its purpose. Operating networks will have more detail than networks prepared for top management use.

The network serves many functions but among the principal ones are a graphical representation of the program plan, a communication tool for the performing and managerial staff involved, and a basis for control by management.

Once the network is finalized, the next step is to establish a time frame for the total project or program duration. Depending on which specific network system (PERT or CPM) is to be employed, single or multiple time estimates (usually three) are secured for each of the individual tasks assuming resources as planned or available and under a normal resource application rate (e.g. 40 hr. week) from those persons who are to do the task. Single estimates are referred to as deterministic estimates while multiple estimates are known as probabilistic estimates. The latter estimating procedure has the advantage of helping us to deal with the uncertainty problem which characterizes much research and development work. When three time estimates are secured, an average estimate is obtained along with a measure of the variability of the estimates by the application of appropriate formulas.

After the single or average time estimates are secured for each task, they are utilized to find the total time for the project as well as the time needed for the start/completion of each event in the network. There is one set of tasks in the network that is the most time consuming. This set of tasks is referred to as the critical path. In addition to the critical path, we are able to determine the amount and location of slack existing within the network. Slack refers to the difference between the earliest time an event can take place and the latest allowable time it can take place without jeopardizing project completion. While diamonds may be a girl's best friend, slack is one of the best friends a manager can have.

Once the time frame is established, schedule dates are set up for the start and completion of work after consideration is given to resource requirements needed for the various activities in the total program or project and their availability. Once the schedule has been established, work on the project now begins.

Successful completion of the above tasks done in the planning stage provides the information needed for the data base of the triangle referred to earlier. As I prefer to say, the "shoulds" for the project or program have been established.

The second stage of implementation, that of control, begins once work on the project is initiated. Periodic reports are prepared which reflect actual status of the project schedules with regard to work completed, work in progress, and work yet to be done. These reports are summarized and presented to management in both graphic and narrative form with a primary emphasis upon the exception-reporting principle. That is, the reports presented to management are so organized that only the most serious problems (i.e., deviation of performance from plan or actuals from shoulds) are presented for management consideration and decision. Solutions to these problems usually take the form of adding resources, redefining tasks, eliminating tasks, or paralleling tasks which originally were in linear order. Considerations of time/cost/performance trade-offs are made at this time. Once management action is taken, necessary revision or changes in the project or program network are made, new time estimates secured, and new schedules established. Work then continues until the next reporting period and so on until the program or project objective is reached.

The above is admittedly a brief description of network systems but additional information can be obtained from a reference such as that by Archibald and Villoria (2) or from a monograph (4) describing the applicability of network systems to the field of education and distributed by the U.S. Office of Education. I hope that sufficient description has been provided so that you can see that network techniques meet the requirements of the three tasks as set forth earlier and meet criteria for a management information system. It should be pointed out here that network systems have been expanded to include the planning and control of costs with some exploratory work being done to include the planning and control of performance but time again prevents us from presenting details on these procedures.

It can be stated that network techniques with their analytical and diagrammatic approaches to the problem of planning and control assist management with the following kinds of tasks:

1. defining the work to be carried out

2. producing better schedules based on available and needed resources

3. making decisions about the best way to apply resources to achieve program objectives

4. monitor progress and identify those points where delays could jeopardize the project in time to permit corrective action to be taken (6).

It is only fair to point out that not everyone is in agreement with the idea that management systems in general and network techniques in particular have any value for planning educational changes. Such objections center on the idea that one cannot identify the objectives as precisely as the system requires, that many of the tasks to be accomplished are not determinable let alone definable so that useful time estimates can be secured, and that one cannot plan nor schedule intellectual and creative work. Such objections may have validity for many research and development programs, even including those in the field of education. The successful employment of such techniques in education has, however, demonstrated that network systems do have validity and relevance for many education problems. Coupled with system analyses techniques, network systems are highly potent tools for bringing about desired improvements in education.

An Illustration

The concepts of program planning and evaluation, managerial techniques, and their relations to systems analysis procedures have been reviewed briefly. You might well ask how do these all operate conjointly to bring about changes in the field of education.

Let me try to answer this question by using an over-simplified illustration. Let us suppose that you are concerned with the improvement (or change to use present day pedagese) of student achievement. Through systems analysis, you have established criteria of performance which are quantified for later evaluation. Having taken this step, you now consider the means-ends alternatives available to you. One could employ televised instruction, computer-assisted instruction, team teaching, and so on. Let us assume that the results of your deliberation indicate that team teaching is the highest ranking alternative (notice that I do not say best). So your mission objective is to implement team teaching in your school district. Through function and task analysis, the many functions and tasks that have to be carried out during the period of implementation have been identified and the mission profile prepared.

At this stage of the game, you are now ready for a management system to help you with the job of actual planning and controlling the implementation. Using network systems, the work breakdown structure is established, the network drawn, time estimates secured, schedules set up, and resources allocated, critical milestones identified, and reporting systems prepared. Once under way, the manager will have to evaluate and review how the implementation process is going. Is he ahead or behind schedule? Because of unforeseen problems such as a strike by the local teachers or the nonavailability of a consultant, are changes on the plan required? Periodic reports prepared for management will not only appraise him of present problems but will also identify potential future problems. Carefully prepared progress reports and their proper utilization by our school district superintendent will go a long way in making sure that the implementation of the team teaching

program will have actually taken place by the date he has established and within the projected costs.

While over-simplified, the above illustration does incorporate the three concepts that I have been asked to deal with this afternoon. Systems analysis is used to help decide what the objective is, the most feasible alternative to achieve it, and the many tasks which must be done along with their logical sequence. Management techniques will help us to plan the program in terms of how we intend to proceed and then help us to control or stay on top of the operation. Using this technique, we can bring together both professional substantive competence and managerial skills so that our programs of planned change can become living evidence of our efforts.

Conclusion

To conclude this presentation, it seems imperative to me that if we are going to bring about improvements or changes in the field of education they must, of necessity, be both planned and controlled. The employment of systems analysis and synthesis procedures offer a challenge and an opportunity to improve our planning effort. Such techniques force us to face up to the question of what exactly is it that we want to accomplish and how we intend to go about it. The specification of the objective and its subsequent analyses to identify the functions and tasks which have to be accomplished in order to reach the objective require us to use our logical skills to a very high degree.

Once the analysis is made, we are only partly along the road. The operations necessary to bring about the change or accomplish the objective have to be initiated and carried out. This situation requires selection and employment of some management system or technique to make sure that the plan is accomplished within the time/cost/performance constraints that are present or established. Employment of new and highly successful management techniques commonly called network-based systems, specifically PERT and Critical Path Method, provide a means of meeting this end.

The focus of this symposium is on planning for educational change and on the preparation of educational planners. As noted above, planning implies control. Because of this relationship, educational planners should be knowledgeable about and competent in the tools and techniques of management if there is to be assurance that the program goals that have been estabiished are to be accomplished. I hope that my remarks today have stimulated each of you to become interested in securing proficiency with such management techniques.

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